

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

REC'D 23 AUG 2005

PCT

Applicant's or agent's file reference 38569/268117		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US 03/25029	International filing date (day/month/year) 08.08.2003	Priority date (day/month/year) 08.08.2003	
International Patent Classification (IPC) or both national classification and IPC F02B37/12			
Applicant HONEYWELL INTERNATIONAL INC. et al.			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 22.09.2004	Date of completion of this report 22.08.2005
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Pileri, P Telephone No. +49 89 2399-7907



**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. **PCT/US 03/25029**

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, Pages

1-10 as originally filed

Claims, Numbers

1-19 received on 22.06.2005 with letter of 22.06.2005

Drawings, Sheets

1/10-10/10 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. **PCT/US 03/25029**

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-19
	No: Claims	
Inventive step (IS)	Yes: Claims	1-19
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-19
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

**Reasoned statement with regard to novelty, inventive step or industrial applicability;
citations and explanations supporting such statement**

1 Reference is made to the following documents:

- D1: PATENT ABSTRACTS OF JAPAN vol. 2002, no. 04, 4 August 2002 (2002-08-04) & JP 2001 355453 A (TAKEMOTO SHIGETO), 26 December 2001 (2001-12-26)
- D2: GB-A-2 244 312 (MOTOREN TURBINEN UNION) 27 November 1991 (1991-11-27)
- D3: GB-A-2 163 483 (SOLEX) 26 February 1986 (1986-02-26)

2 The document D3, which is regarded as being an important document, shows a system for supplying compressed air to a combustion engine whereby a recirculation line is arranged to recirculate a portion of the compressed air to the compressor air inlet. A bypass control valve is provided in the recirculation passage to control flow through the recirculation passage.

The subject-matter of claims 1 and 16 differs from this known prior art in that the recirculation valve is open when the engine is operating below a threshold engine speed and closed when the engine is operating above said threshold engine speed.

The subject matter of claims 1 and 16 is new in sens of Article 33(2) PCT.

In D3 the recirculation valve is controlled so that the pressure would be high when the engine load demand is high and would be low when the engine load is light. The recirculation valve is therefore closed when the engine load demand is high and open when the engine load is light.

In D1, which is also considered an important document, the recirculation valve is open when the compressor discharge pressure is above a predetermined threshold, this occurs however regardless of speed.

3 The object of the present invention is to avoid compressor surge.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/US 03/25029

The solution proposed in claims 1 and 16 of the present application involves an inventive step. The control of the recirculation valve as described in the claims is in fact neither described nor suggested by the documents cited in the search report.

- 4 The invention is industrial applicable.

THAT WHICH IS CLAIMED:

1. A system (10) for supplying compressed air to an internal combustion engine (14) so as to boost power output by the engine, said system comprising:

a compressor (11) having a rotary compression device (30) positioned in a housing (24) defining an air inlet (23) and a compressed air outlet (32), wherein the air inlet (23) is configured to supply inlet air to the rotary compression device, wherein the rotary compression device is configured to compress the inlet air and wherein the compressed air outlet is configured to allow the compressed air to exit the housing for supply to an intake of the engine;

a recirculation line (18) arranged to recirculate a portion of the compressed air discharged from the compressed air outlet (32) back to the compressor air inlet (23);

a recirculation valve (22) disposed in the recirculation line (18) and operable to control rate of flow through the recirculation line, the recirculation valve being controllable via control signals;

a programmed controller (21) in communication with the recirculation valve (22) and programmed to send control signals to the recirculation valve to open the recirculation valve so as to recirculate compressed air through the recirculation line (18) to the compressor air inlet (23) when the engine is operating below a threshold engine speed, and to maintain the recirculation valve closed so as to prevent recirculation when the engine is operating above said threshold engine speed; and

an air cooling device (50) connected in fluid communication with the recirculation line (18) and operable to cool the recirculated air upstream of the compressor air inlet (23), wherein the cooled air from the recirculation line is combined with the inlet air upstream of the compressor air inlet, the cooled recirculated air reducing occurrence of compressor surge.

2. The system of Claim 1, wherein the controller (21) is programmed to control an amount of the valve opening (RVO) of the recirculation valve (22) as a function of the engine speed and the outlet air pressure.

3. The system of Claim 2, wherein the controller (21) is programmed to control the amount of valve opening (RVO) according to the equation:

$$RVO = A/N_e + B/P2C$$

wherein A and B are predetermined constants, N_e is the engine speed and P2C is the outlet air pressure.

4. The system of Claim 1, further comprising a compressor discharge line (13) connecting the engine intake and the compressor outlet (32), wherein a first end (27) of the recirculation line (18) is connected to the compressor discharge line (13) and wherein the air cooling device (50) is connected in fluid communication with the compressor discharge line (13) upstream of the recirculation line (18) first end and compressor discharge line (13) connection.

5. The system of Claim 1, further comprising a compressor inlet line (12) connected to the compressor air inlet (23), wherein a second end (28) of the recirculation line (18) is connected to the compressor inlet line (12).

6. The system of Claim 5, further comprising a mixing device (20) connected to the recirculation line (18) and the compressor inlet line (12) and operable for mixing cooled, recirculated air from the recirculation line with inlet air from the compressor inlet line.

7. The system of Claim 6, wherein the mixing device (20) is an air cleaner.

8. The system of Claim 6, further comprising an air cleaner (49) connected to the compressor inlet line (12) upstream of the mixing device (20).

9. The system of Claim 1, further comprising a compressor discharge line (13) connecting the engine intake and the compressor outlet (32), wherein a

first end (27) of the recirculation line (18) is connected to the compressor discharge line (13) and a second end (28) of the recirculation line is in fluid communication with the compressor air inlet (23), and wherein the air cooling device (50) is disposed between the first end (27) and the second end (28) of the recirculation line (18).

10. The system of Claim 1, further comprising a compressor inlet line (12) connected to the compressor air inlet (23), the recirculation line (18) being connected to the compressor inlet line (12), and further comprising an air cleaner (49) connected to the compressor inlet line (12) downstream of the recirculation line (18) and compressor inlet line (12) connection, and wherein the air cleaner (49) is also configured to mix recirculated and inlet air.

11. The system of Claim 10, further comprising a compressor discharge line (13) connecting the engine intake and the compressor outlet (32), wherein the recirculation line (18) is connected to the compressor discharge line (13).

12. The system of Claim 11, further comprising a second air cooler (19) connected in fluid communication with the compressor discharge line (13) downstream of the recirculation line (18) and compressor discharge line (13) connection.

13. The system of Claim 11, further comprising an exhaust gas recirculation line (17) connected to the compressor discharge line (13) downstream of the connection between the recirculation line (18) and compressor discharge line (13).

14. The system of Claim 13, further comprising an exhaust gas cooling device (42) connected to the exhaust gas recirculation line (17).

15. The system of Claim 14, further comprising a second air cooling device (19) connected to the compressor discharge line (13) downstream of the recirculation line (18) first end (27) and compressor discharge line (13) connection

and upstream of the exhaust gas recirculation line (17) and compressor discharge line (13) connection.

16. A method of actively controlling compressor surge in an engine system wherein air is compressed in a compressor (11) and supplied to an intake of an internal combustion engine (14), said surge controlling method comprising the steps of:

- supplying air to a compressor inlet (23) of the compressor (11);
- compressing the air in the compressor;
- discharging the compressed air from the compressor through a compressor discharge line (13) to the intake of the internal combustion engine (14);
- providing a recirculation line (18) connecting the compressor discharge line (13) to the compressor inlet (23);
- providing a controllable recirculation valve (22) in the recirculation line (18) for controlling an amount of flow through the recirculation line;
- opening the valve (22) and recirculating compressed air from the compressor discharge line (13) to the compressor inlet (23) when the engine (14) is operating below a threshold engine speed, and maintaining the valve (22) closed so as to prevent recirculation when the engine (14) is operating above said threshold engine speed; and

cooling the recirculated air prior to delivering the recirculated air to the compressor inlet (23).

17. The method of Claim 16, further comprising mixing the cooled recirculated air with the air being supplied to the compressor inlet (23) such that flow conditions entering the compressor (11) are more uniform than would exist without said mixing.

18. The method of Claim 16, wherein an amount of the valve opening (RVO) of the recirculation valve (22) is a function of the engine speed and the outlet air pressure of the compressed air discharged from the compressor (11).

19. The method of Claim 18, wherein the amount of valve opening (RVO) is controlled according to the equation:

$$RVO = A/N_e + B/P_{2C}$$

wherein A and B are predetermined constants, N_e is the engine speed and P_{2C} is the outlet air pressure.